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(54) **Electroluminescent lamps and panels.**

(57) A flexible electroluminescent lamp or panel has a base (10) of flexible polyester material. A transparent electrode (12) on the base is formed in a pattern (18) of segments (12a) connected by conducting portions (19a). A phosphor resin layer (25) is applied to the transparent electrode only in the lighted areas (12a). A dielectric layer (28) is applied over the phosphor layer, either over the entire panel or over the areas to be protected. A second electrode layer (30) in the form of a conductive resin is applied in complementary fashion over the lighted areas (12a) and is formed with conducting or joining segments (31). A final conformal coating (45) is applied over the panel. An area (29) of the transparent electrode (12), along one of the connecting segments (19a) provides a region for the direct attachment of a power lead (35) inwardly of the marginal edges of the panel.

Each of the resin layers of the lamp or panel is formed of the same compatible resin material to form a homogeneous resin layer.

Fig. 2

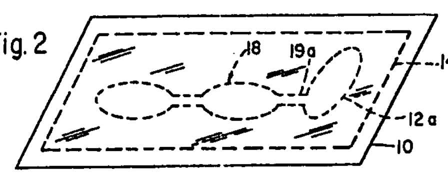



Fig. 5

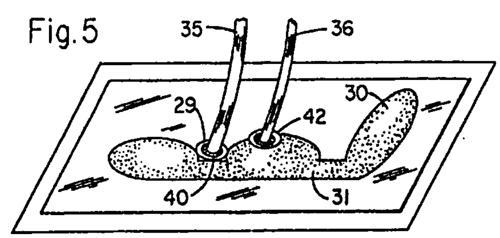
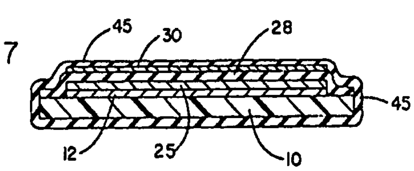



Fig. 7

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# ELECTROLUMINESCENT LAMPS AND PANELS

This invention relates to electroluminescent lamps and panels, and more particularly to flexible electroluminescent lamps and panels and to methods of making the same.

The cost of making electroluminescent lamps and panels may be attributed to the inefficient use of relatively high cost materials, such as semi-precious metals and phosphors. Where less than the full surface of a panel is used, it has been a practice to mask the unused portion, which is wasteful both of materials and of power required to drive the lamp.

The conventional placement of the electric power leads is at the edges of the panel. However it may be desired to bring the power leads into the panel remote from the edges. Internal lead placement has usually involved only the power lead to the back electrode.

Electroluminescent lamps and panels have been made in which only portions of the panel areas are energized, to form a pattern of lighted areas. Selective lighting or decoration has been achieved by configuring a back metal electrode into segments of the desired pattern, with individual power leads attached to the metal segments as required, as shown in U. S. Patent No. 3,133,221 issued May 12, 1964 to Konosho et al and U. S. Patent No. 3,225,644 issued June 13, 967 to Buck, Jr. et al. No attempt is made to restrict the areas of application of the phosphor, or the size or limits of the transparent electrode to conform to the pattern. Therefore, a substantial area of phosphor remains unused, and the unused area of the transparent electrode increses the likelihood of short circuits or accidental groundings.

The present invention overcomes many of the shortcomings of presently available lamps and panels. In one aspect of the invention, each of the operative layers of a flexible electroluminescent panel is formed with a resin carrier which is compatible with that of each of the other layers in that the resin carrier of each layer has basically the same physical, chemical and electrical properties as those of the other layers. As a result of using the same resin carrier in each polymer layer the compl ted electroluminescent panel is homogeneous throughout all such layers, with no discernible difference between the crystalline structure of each of the layers apart from a filler material, such as phosphor, pigment, dielectrics, or metal.

The resin may be a casting polyester which is activated by a relatively small quantity of diisocyanate, such as toluene diisocyanate. Such resin has been found to have excellent adhesive to the polyester base sheet such as "Mylar," to which a metalized transparent electrode, such as a indium-oxide, has been applied. Such resin material has further been found to have a high dielectric constant, providing excellent lamp brilliance, coupled with excellent moisture protection and long service life. The quantity of toluene diisocyanate used is insufficient to form a urethane, but is advantageous in enhancing the temperature stability of the panel, and in making a resin layer which is somewhat more durable for handling purpose after curing. However, good results have been obtained where the diisocyanate has been omitted.

In a further aspect of the invention, the electroluminescent lamp is designed to emit light only in discrete areas, for the purpose of producing a pattern of light, which pattern occupies less than the full surface area of the panel. It is advantageous to remove certain areas of the transparent electrode, such as by acid-etching, to form a remaining area, in which portions of the electrode correspond to portions of discrete areas of the lamp to be illuminated are joined by electrically connecting segments so that the individual portions may operate as a single electrode from a single electric lead from the power supply. Thereafter, a phosphor-carrying polymer resin is applied in a pattern corresponding to such discrete areas of the design to be illuminated as a part of the lamp, in superimposed relation to corresponding portions of the transparent electrode.

A dielectric layer is then applied over the phosphor layer. The dielectric layer may be applied discretely, as in the case of the phosphor layer or, for the purpose of encapsulating and sealing the phosphor, or it may be applied over the entire exposed surface of the panel. The dielectric layer is a carrier for a pigment, such as barium titanate, to provide a white reflective backing surface, for redirecting light from the phosphor through the transparent front electrode and the transparent polyester base. The barium titanate also increases the overall dielectric constant of the lamp.

A second, non-transparent, electrode is applied over the dielectric layer using a compatible polymer resin carrier, and may contain metal in the form of flaked silver, nickel or the like, to form a back electrode. In this manner, only portions of the lamp which are illuminated (in accordance with the desired pattern), thereby effecting savings in the amount of materials applied for a given design of lamp, and at the same time, effecting a savings in the power which would otherwise be required to drive the lamp.

Preferably, each operative resin layer is dried or cured before the next layer is applied, followed

by the curing of the conforming or sealing layer, to form a completed panel. The individual resin layers may be applied by silk-screening.

The panel of this invention is characterized by the fact that the application coatings are limited to discrete areas of the panel, in accorance with a predetermined pattern or design. This confines costly phosphors, conductive silvers, or other ingredients to discrete areas of the panel, corresponding to the desired pattern or design. In the case of the electrodes, additional connecting segments, as required, are formed to assure continuity of the respective electrodes and associated lead connections. The connecting electrode segments may be offset from each other to reduce coupling at these areas where no light output is desired.

A further aspect of the invention relates to the attachment of power leads to the panel electrodes. Commonly, one or more of the power leads are attached to bus bars. However, in panels formed with complex lighted patterns, it is difficult or inconvenient to apply a bus bar which is electrically connected to the transparent electrode, and it is desirable to make a lead attachment directly to the electrode at a location inward of the panel margin. An area of the transparent electrode is selected for subsequent lead attachment. This area may be on a connecting segment or portion on the electrode outside of the lighted regions. This selected area is thereafter protected from subsequent coatings, by blocking the area on the printing screen or masking the area. After the back electrode has been applied, and optionally after a conformal coating has been applied and the panel trimmed, the power lead is applied to the selected area by pressing a portion thereof against the exposed electrode area and applying a conductive adhesive. Preferably localized heat is applied to bond the lead. A compatible bonding resin assures good attachment without lifting, as the same resin forms a structural adhesive and electrical connection. A second power lead may be attached to the back electrode using the same application technique, either at a marginal location or at a convenient location inwardly of the panel margins.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in which:

Figs. 1-6 illustrate the steps in the manufacture of a panel according to this invention in which:

Fig. 1 shows a transparent electrode coated base film and an acid-resist coating baked on the surface to define a discrete pattern;

Fig. 2 illustrates the panel of Fig. 1 following etching and removal of the resist coating;

Fig. 3 illustrates the panel after the application of phosphor at discrete locations of the panel;

Fig. 4 illustrates the panel of Fig. 3 following the application of a pigmented dielectric layer;

Fig. 5 illustrates the panel of Fig. 4 following the application of the second or rear conductive electrode and after the application of leads;

Fig. 6 shows the completed panel of Fig. 5 looking at the front side thereof following the application of a conforming coating, trimming and following the application of decorative graphics on the front surface; and

Fig. 7 is a transverse section through the panel taken generally along the line 7--7 of Fig. 6.

Referring to Fig. 1, a base 10 comprises a sheet of temperature stabilized polyester film, such as "Mylar", which may for example be 5 mils thick, to which has been vacuum deposited on the surface an indium-oxide layer 12 (Fig. 7) to form a transparent electrode. It is understood that other transparent electrode materials may be used, such an indium-tinoxide or gold. The electrode 12 has a resistance in the order of 100-200 ohms per square. The layer 12 forming the electrode is shown in Fig. 7 in exaggerated thickness, and is only a few Angstroms thick. The sheet of polyester film is cut to size, such as by using a steel rule die, to form the base 10 which may be slightly larger than the finished size of the completed panel, as illustrated by the margin 14 in Fig. 1.

The completed panel has lighted regions which form a design or pattern: in this case, two longitudinally extending oval areas and one transverse oval area, for the purpose of illustration. Reference numeral 18 designates the lighted pattern generally, although it is understood that the lighted areas may take any desired configuration, or may, where desired, occupy the entire operative surface of the panel.

After the base 10 has been cut, the exposed surface of the transparent electrode layer 12 is cleaned, such as with isopropyl alcohol, and is then coated with an acid resist coating 19, as shown in Fig. 1, to define the desired configuration of the transparent electrode following removal of the remaining portion of the electrode by acid etching. It will be seen that the electrode area corresponds generally to the design 18, with intermediate connecting segments 19a to provide electrical continuity between individual portions which will become the lighted areas of the design. It is preferred to apply the acid resist by silk-screening.

The acid resist coating is cured such as by heating to a temperature of 95° C for a minimum of five minutes. Thereafter, the remaining portion of the transparent electrode 12 is removed by acid etching in diluted hydrochloric acid and rinsed to neutralize any remaining acid. If desired, an alkali acid neutralizing solution may be used. Next, the acid resist coating 19 is removed by a conventional

paint remover or solvent for the resist and neutralized as necessary. The panel now has the appearance as illustrated in Fig. 2 in which the base 10 has remaining on is surface the electrode 12a now configured as shown by the broken lines, the remaining portion of the transparent electrode having been removed.

The front electrode 12 may be screen printed to form a bus bar, if desired, or to form electrical terminal contacts if conventional contacts are to be used. The carrier resin material should be adequately cured and dried in an inert atmosphere, as described below. Also, the resin carrier used for this step should be identical to the resin carrier described below, in connection with the application of subsequent layers.

The phosphor layer 25 is now applied. As shown in Fig. 3, the phosphor layer is formed in discrete portions which correspond essentially to the desired design or light pattern 18, and is therefore preferably applied by silk-screening.

The phosphor layer 25 employs a polymer resin carrier, which carrier is preferably a polyester laminating resin, such as Morton Adcote 503A made by Morton Chemicals Company, 2 North Riverside Plaza, Chicago, Illinois 60606, United States of America, or the No. 49001 Polyester Resin, a laminating polyester resin of E. I. duPont de Nemours and Company, Fabrics & Finishes Department, Wilmington, Delaware 19898, United States of America. Preferably, the identical laminating resin is used for each of the subsequent layers to assure the chemical and thermal compatibility of each layer, to the end that the layers combine to form a homogeneous continuous thickness of integrated uniformity and integrity.

In preparing the resin carrier, polyester adhesive resin is solubilized by adding cyclohexanone in equal parts by weight to the resin and the mixture is then milled until a homogeneous mixture is obtained. A wetting agent may be added to improve adhesion to the pigments and to the polyester substrate base 10. The wetting agent may consist of up to 1.0% by weight of Union Carbide Company's 1100 Silane, which is thoroughly mixed with the resin-solvent. Additionally, a flowing and anti-foam agent may be added to improve silk-screening qualitites. Eastman Kodak's "EKtasolve" DB acetate (diethylene glycol monobutyl ether acetate) is added at a ratio of 1:1 by weight to the above resin mixture as a flowing agent and antifoamant. At this point, the resin carrier is prepared for use or storage.

It is preferred to add a small quantity of toluene diioscyanate, as an activator and curing agent, for the purpose of temperature stability to increase curing rate and to improve the handling characteristics. It is also believed that the diisocyanate may improve the dielectric qualities. Morton Chemical's Catalyst F, a toluene diisocyanate, may be used, 1.22% of total weight to 24.44% by weight of the prepared resin carrier previously described. This consists of approximately 5% by weight of the polyester adhesive resin, and may be considered to be a relatively small quantity of diisocyanate, which is insufficient to convert any substantial portion of the polyester into a polyurethane. In any event, it is preferred that no more than about 5.0 parts by weight of catalyst F be used to 100 parts by weight of polyester resin. If desired, duPont's RC 803 isocyanate curing agent containing toluene diisocyanate in an ethylene acetate solvent may also be used in lieu of Morton Chemical's Catalyst F. This mixture is now completely mixed by a high shear mixture and then degased for twenty minutes in a vacuum of at least 26" (880 millibars) of mercury. In the above-described basic polymer mix, which defines the preferred polymer carrier for each of the layers, cyclohexanone thinner is particularly advantageous for a silk-screening operation as it permits sufficient working time to coat the particles and prolong screen life.

The phosphor layer 25 is prepared by using resin carrier, described above, into which an appropriate phosphor has been blended. Typically, the phosphor has been washed and dried in an inert dry atmosphere, such as nitrogen, at 230° F (110° C) and blended with the prepared resin carrier in the ratio of about 70% phosphor by weight to 23% carrier by weight. Following mixing, the mixture is degased in a vacuum, as previously described, and applied to the exposed surface of the transparent electrode 12 to define the discrete areas of the pattern, as shown in Fig. 3. The resin-laden phosphor layer 25 is now dried at 90° C in an inert atmosphere, such as dry nitrogen, for 1 hour. Force drying, using an in-line dryer, can also be used to shorten the drying time.

A dielectric layer 28 is now applied over the phosphor layer 25. Preferably, the identical polymer casting resin is used as a carrier, made as described above. The dielectric layer may include a pigment, such as barium titanate, to form a pigmented dielecric layer, with particles of the pigment in the polyester carrier. The layer 28 may be applied over the back surface of the base sheet 10, or if desired, may be limited to the discrete areas defined by the transparent electrode 12 as shown in Fig. 2. However, where leads are to be attached at a location other than the panel edge, a lead access uncoated area 29 is chosen. This area is blocked out by a suitable portion of the screen, or protected by a mask, to provide access for connecting one of the power leads to the transparent electrode 12. In the preparation of the coating 28,

polyester casting resin prepared as previously described is blended with dried barium titanate at a ratio of 1:1 by weight, and degased as previously described. After application this layer is cured in the same manner as described for the phosphor layer 25.

Following the application of the pigmented dielectric layer 28, the second or back electrode layer 30 is applied to the dielectric layer. This electrode layer is preferably screened on and is confined to the regions of the design represented by the phosphor layer, with a suitable interconnecting segment 31 as shown in Fig. 5. Preferably, the interconnecting segment 31 is laterally offset on the panel from the corresponding connecting segments 19a of the transparent elecrode 12 to reduce coupling therebetween. The above-defined resin mixture is preferably used as the polymer carrier to which a metal conductor has been added to define the rear electrode. In a typical electrode mixture, flaked silver is thoroughly dried and mixed with the base resin in a ratio of 67% silver by weight to 33% resin base by weight, and the mixture degased in a vacuum as previously described in connection with the resin mixtures for the preceding layers. After application, the second electrode layer 30 is cured in the manner previously described. The back electrode will have a low resistance of above five ohms per square.

It may now be determined whether or not power leads are to be applied to the panel. If the panel is to require further handling, such as the application of graphics or legends on the front surface of the panel, as illustrated for example by the graphics 34 shown in Fig. 6, or if the panel is to be die cut or trimmed to size, it may be preferred to defer the attachment of the leads until such further handling is completed. However, if the leads are to be applied at this stage in the processing of the completed panel, they may now be directly attached to their respective electrodes. Fig. 5 illustrates the leads 35 and 36 after attachment. The lead 35 is connected to the transparent electrode within the protected and preselected area 29 formed on one of the interconnecting segments 19a of the transparent electrode 12. The end of a braided copper lead is preferably bent over and held against the electrode and a small amount of conductive epoxy adhesive 40 is applied on the end of the lead and on the electrode. Preferably, the same material which is used to form the electrode layer 30 is employed as the attaching conductive adhesive 40. This is heated locally, after application, to effect partial drying or curing, care being taken to avoid any shorting contact with the adjacent back electrode layer 30. This connection area may, if desired, be coated with a dielectric clear coating of the same polyester casting resin and dried.

Lead 36 is similarly connected to the back electrode 30 at any convenient location by the application of a quantity of adhesive resin 42 which may again be the resin and conductive metal mixture used in the making of the electrode layer 30. Again, localized heating may be employed to cure and set the resin with the lead attached.

A conformal coating 45 for moisture carrier may be applied either prior to or after lead attachment. If applied prior to, it remains necessary to block by screen printing or by masking the preselected areas for lead attachment. The screen may be dipped in Kel-F 800, a polytetrafluoroethylene barrier resin of Minnesota Mining & Manufacturing Company, or may be screen-printed with this material as a barrier. Dow Corning Company's Saran HB film material may be used as a laminate barrier in lieu of the screen-printed or dipped barrier.

The completed panel now comprises operative layers which are each essentially of the same chemical composition with respect to the polymer base resin or material. When a cross section of a panel made according to this invention is examined with a scanning electron beam microscope, it is seen that each coating blends continuously into the next to provide a homogeneous panel construction which is free of dissimilaraities between layers and providing an integrated uniformity to the layers.

A pattern applied to an electroluminescent lamp in accordance with the teachings of this invention may be more complex than that illustrated in the drawings. It may have a variety of illuminated areas of different sizes and shapes, for the purpose of accomplishing a desired result. For example, in an automotive radio panel, only the portions of the panel which designate control functions, such as volume, on-off, balance, base, treble, and various touch key functions may be illuminated. Therefore, the areas of active phosphor may be small compared to the overall area of the supporting base. Similarly, the interconnecting electrode segments may constitute a significant portion of the overall area,. and as previously noted, these segments may be laterally offset from each other to reduce capacitive coupling and thereby reduce the overall load on the power supply. The panel may be die cut, even in the areas of the electrodes with minimal risk of shorting between the electrodes. For example, a lighted portion of the flexible panel, defining a rectangular area, may be cut along three sides so that such portion may be folded back along an uncut fourth side and used to backlight an LCD display which may be inserted within such rectangular area.

## Claims

1. A flexible electroluminescent lamp, including a light panel with a flexible polyester base (10), a transparent electrode (12) on said base, a phosphor layer (25) on said transparent electrode, a pigmented dielectric layer (28) on said phosphor layer, and a back electrode (30) on said pigmented layer, the improvement characterized by the fact that the transparent electrode (12) is formed in a pattern (18) which partially covers the surface of said base, the phosphor layer (25) is formed in a complementary pattern in alignment with the transparent electrode, and the back electrode layer (30) is also formed in a complementary pattern in alignment with said phosphor layer.

2. The lamp of claim 1 further characterized by a connecting segment (19a) of the transparent electrode positioned on said base inwardly of the margin and a power lead (35) for said lamp having an end bonded to the transparent electrode at a contact area (29) on the segment, surrounded by the dielectric layer and in non-overlapping relationship with said back electrode layer.

3. The lamp of claim 2 in which a second power lead (36) is joined to the back electrode layer (30) at a location inwardly of the margins of said back electrode.

4. The lamp of any preceding claim further characterized by the fact that each of said layers (25, 28, 30) consists of a polyester laminating resin, containing no more than 5% diisocyanate by weight.

5. The lamp of any preceding claim further characterized by the fact that the phosphor layer has phosphor particles in a polymer carrier, the dielectric layer including particles of pigment in a polymer carrier compatible with the carrier of the phosphor layer, the back electrode layer including particles of metallic conductor in a polymer carrier compatible with the carrier of said dielectric layer, and a conformal sealing layer (45) covering the back electrode layer.

6. The lamp of any preceding claim in which connecting segments of the back electrode layer are offset from connecting segment of the transparent electrode to reduce electrical coupling therebetween.

7. The method of making a decorative electroluminescent lamp or panel in which the area of the panel to be lit is formed into a plurality of discrete or separate portions (18) to be lit at least partially surrounded by portions of the panel not to be lit, thereby to form a pattern of light, and in which a transparent electrode (12) is formed on one side of a flexible base sheet (10), and an electroluminescent phosphor layer (25) is formed on the transparent electrode, a dielectric layer (28) is formed on the phosphor layer, and a second or back electrode layer (30) is applied to the dielectric layer, the improvement comprising the steps of forming the transparent electrode, the phosphor layer, and at least the second electrode layer in patterns corresponding to the pattern of said area to be lit and providing suitable connecting portions joining together the separate active areas of said electrodes.

8. The method of claim 7 in which the phosphor electrode layer, the dielectric layer, and the second electrode layer are formed with the same carrier resin to provide a homogeneous panel.

9. The method of claim 8 in which the carrier resin is a polyester laminating resin.

10. The method of claim 7, 8 or 9 characterized by the further step of applying a power lead to the transparent electrode layer by selecting a lead location are on the electrode layer inwardly of the margins of the panel, protecting the chosen lead location area to prevent coatings thereon, and attaching a power lead to the selected area by applying a conductive resin and heating to set the resin.

Fig. 1

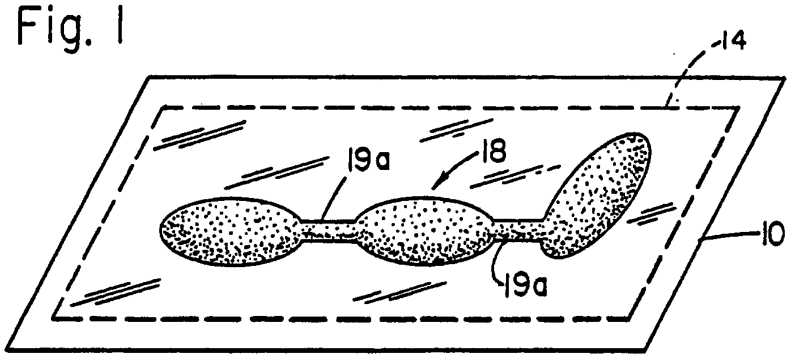



Fig. 2

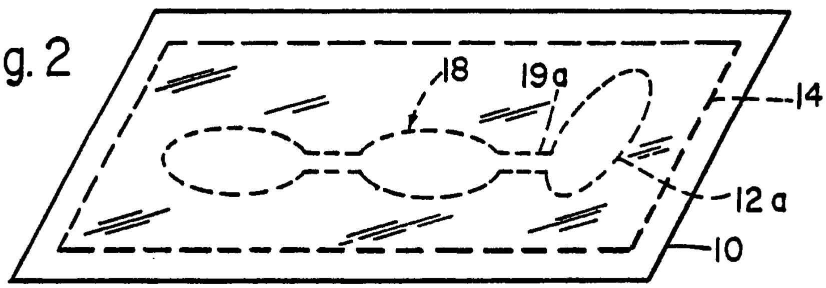



Fig.3

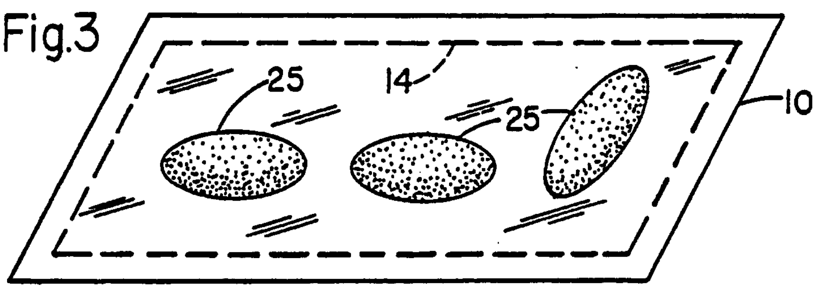



Fig. 4

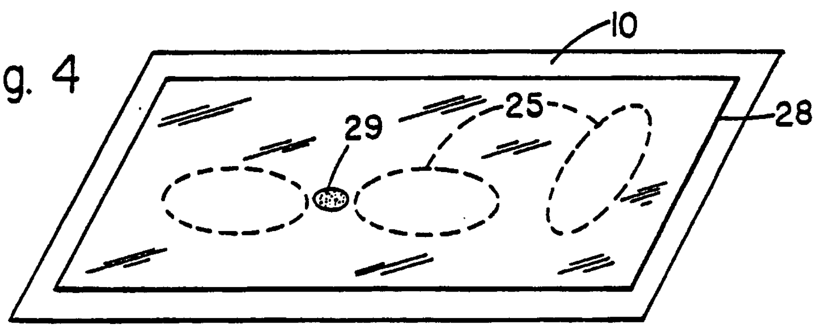


Fig.5

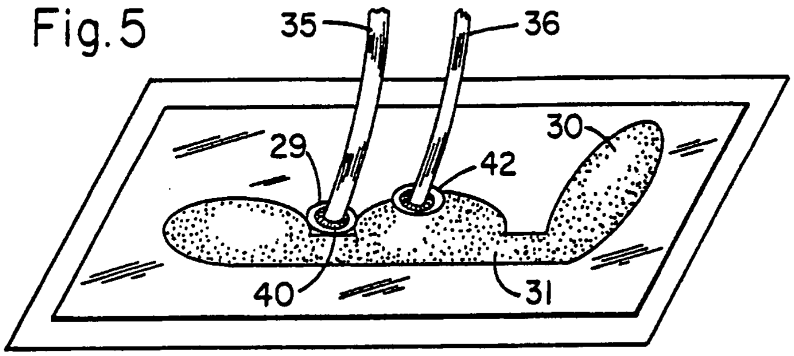



Fig. 6

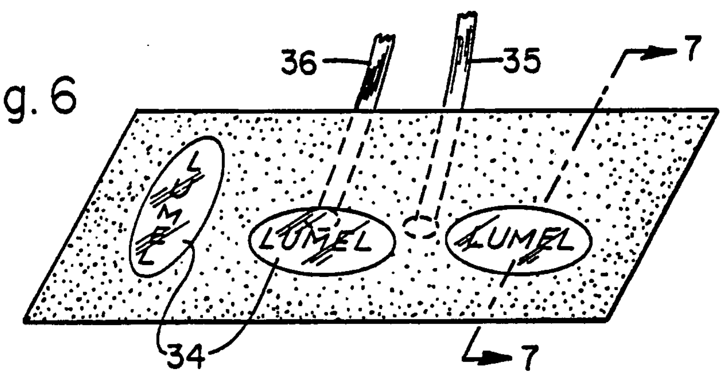
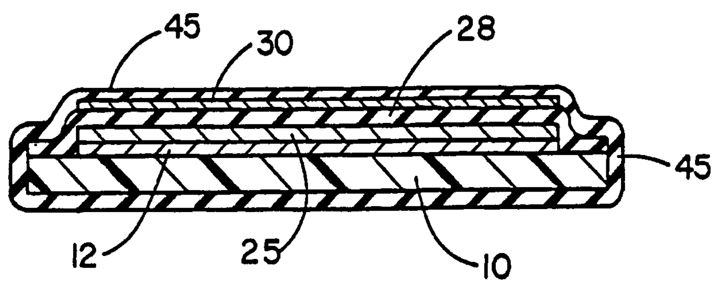



Fig. 7



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# EUROPEAN SEARCH REPORT

Application Number

EP 87 30 3324

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| X | EP-A-0 172 985 (BALL)<br>* Whole document *<br>----- | 1-9 | H 05 B 33/12<br>H 05 B 33/28<br>H 05 B 33/14 |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| | | | H 05 B 33/00 |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 07-12-1987 | DROUOT M.C. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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